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(71) Applicant: **United States Surgical Corporation**  
**150 Glover Avenue**  
**Norwalk, Connecticut 06856(US)**

(72) Inventor: **Sander, Thomas W.**  
**6 Stone Camp Trail**  
**Winona Lake, Indiana 46590(US)**  
Inventor: **Lewis, Royce**  
**5233 West 19th Street**  
**Lubbock, Texas 79407(US)**

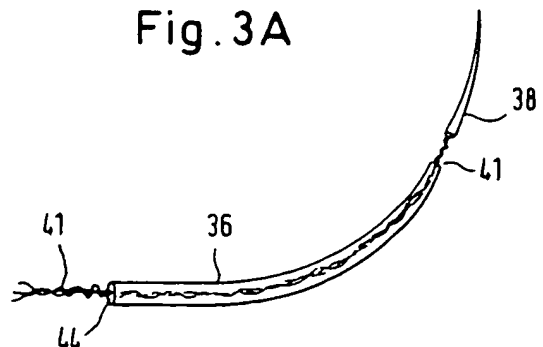
(74) Representative: **Marsh, Roy David et al**  
**Hoffmann Eitle & Partner Patent- und**  
**Rechtsanwälte Arabellastrasse 4 Postfach**  
**81 04 20**  
**W-8000 München 81(DE)**

(54) **Implant assist apparatus.**

(57) An implant assist apparatus is disclosed for implanting material such as a suture (41) in tissue (56) to reapproximate or reinforce the tissue (56). A cannula (36) is provided having a hollow body and an open proximal (24) distal end (44). Point means (38) is detachably fixed to the open proximal end (24) of the cannula (36) for penetrating tissue (56). A method of implanting the material (41) in tissue (56) for reapproximating or reinforcing the tissue (56) with the implant assist apparatus is also disclosed whereby a length of the implant material (41) is attached to a guide wire (40) for partial containment within the cannula (36). The cannula (36) with detachable point (38) is passed into the tissue (56) at an entry point (68) remote from one side of the defect (58,62) and out an exit point (70) on the opposite side remote from the defect (58,62) such that the distal end (44) of the hollow body (36) extends from the entry point (68) and a proximal end (24) extends from the exit point (70). The detachable point (38) is removed from the cannula (36) and a guide wire (40) with implant material (41) attached is drawn out of the proximal end (24) of the hollow body (36) until the implant material (41) is exposed at both the distal

(44) and proximal (24) ends of the hollow body (36). Thereafter, the cannula (36) is withdrawn from the tissue (56) leaving the implant material (41) in place and the implant material (41) is anchored (74) to reapproximate or reinforce the defect (58,62).

**Fig. 3A**



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## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a method and apparatus for effectively joining and/or reinforcing separated soft tissues in humans and animals. More particularly, the invention is directed to a method and apparatus for placement of implants for reapproximating separations in or reinforcing weakened or separated soft tissues normally subject to flexure or strains such as for example, muscles, tendons or ligaments without excessive abrasion.

### 2. Description of Related Art

Currently, end to end repair of elastic tissue such as muscles, tendons and ligaments, separated either by surgical procedure or injury, involves suturing the ends of the tissue together for a time sufficient to permit normal healing. The ends of the tissue are joined with a wide variety of both absorbable and nonabsorbable suture and implant materials. With nonabsorbable suture materials, the sutures are typically removed within one or two weeks of implantation or left in place.

Conventional curved suture needles, with their small radii, significantly limit the distance over which the suture can be buried. This limitation requires that the sutures be positioned proximal to the severed ends of the tissue. Particularly, in the case of soft elastic tissue such as muscles, tendons or ligaments, conventionally implanted sutures have a tendency to prematurely pull through the joined ends of the tissue when it is flexed or subject to slight strains. When this occurs, the tissue ends separate and healing is arrested necessitating further surgery to repair the damage. One particularly advantageous suture for use in joining ends of soft elastic tissue is a braided suture. Braided sutures are well known in the art and are more supple and workable than conventional monofilament sutures for a given tensile strength. Braided sutures, however, tend to abrade these types of soft tissue as they are implanted. It is desirable to be able to introduce a relatively rough-surfaced braided suture without causing tissue damage because, once in place, this type of suture may provide some frictional resistance to pull-out, keep the two ends of the tissue being reapproximated from pistoning and provide a scaffold for tissue ingrowth as healing progresses thus reinforcing the repair.

It is also common to repair, reinforce or replace tendons and ligaments with prosthetic devices, as for example the anterior cruciate ligament. Prosthetic ligaments such as the Gore-Tex cruciate

ligament device are generally implanted through tunnels and anchored at either end. After the tunnels are drilled, it is generally viewed as important to chamfer both the internal and external surfaces to remove sharp edges in an attempt to prevent damage to the prosthesis during placement.

Other common types of procedures involving the reapproximation or reinforcing of tissue ends by implant material include, *inter alia*, patellar tendon reconstruction, collateral ligament repair, knee repair, rotator cuff, tendon suturing, muscle fascia suturing, tendon advancement, reattachment or grafting as well as muscle transfer.

Therefore, it would be highly desirable to have a method and apparatus which permits implant materials of all types to be easily and efficiently positioned in soft or hard tissue over an extended distance remote from ends of the tissue to be joined without excessive abrasion.

Accordingly, it is one object of the present invention to provide an apparatus which facilitates placement of implant materials within soft or hard tissue over extended distances beyond the ends of the tissue to be joined.

It is a further object of the present invention to provide an apparatus which protects the soft or hard tissue and the implant material from abrasion during implantation.

It is another object of the present invention to provide a method and apparatus for implanting an implant material within soft or hard tissue over extended distances without excessive abrasion to the tissue or implant material.

These and other highly desirable and unusual results are accomplished by the present invention in a method and apparatus for implanting an implant material over extended distances within soft or hard tissue to reapproximate and/or reinforce separated ends of the tissue and thus resist the tendency to prematurely pull through the ends of the reapproximated or reinforced tissues when subject to flexure or slight strain. The apparatus and method further permit implantation of a wide variety of implant materials such as sutures, including braided sutures, prosthetic devices such as, for example, tapes, ribbons, braided hollow tubes or other elongated structures, in whole or in part, or tissue augmentation devices without excessive abrasion to the tissue or the implant material.

Objects and advantages of the invention are set forth in part herein and in part will be obvious therefrom, or may be learned by practice with the invention, which is realized and attained by means of instrumentalities and combinations pointed out in the appended claims. The invention consists of novel parts, constructions, arrangements, combinations, steps and improvements herein shown and described.

## SUMMARY OF THE INVENTION

According to the present invention, a method and apparatus is provided for facilitating the reapproximation and/or reinforcing of separated ends of soft or hard tissue of human and animal bodies by placement of implant materials to promote healing. The apparatus comprises a cannula with a removable point releasably attached to one end. The cannula is dimensioned in length, shape and diameter based upon, inter alia, the type of implant material to be implanted, the length of tissue through which the implant material is to pass and the characteristics including shape, of the tissue. For example, in the repair of small tendons or ligaments, a curved cannula approximately four inches in length and 16 or 18 gage in diameter would permit the implantation of a stay suture wherein the suture would extend through the tissue defect and emerge on either end approximately two inches remote from the defect.

The removable point serves to convert the cannula into a hollow trocar to provide smooth passage of the cannula through the tissue, particularly soft tissue, with minimal damage. Further support and guidance through the tissue may be obtained by providing flutes or grooves longitudinally along the outer body of the cannula adjacent the point.

Once the hollow trocar is in position within the tissue to be approximated or reinforced, the removable point is detached, converting the hollow trocar back into a cannula, open at both ends and ready to receive and guide an implant material. The implant material is threaded through the cannula until it is in position with an end of the implant material extending from either end of the cannula. A guide wire may be fixed to the removable point to aid in threading of the implant material through the cannula. The guide wire is attached proximal the base of the point and extends through the cannula, terminating in a loop which is accessible from the end of the hollow trocar.

Implant material ends may also be preattached to the base of the point so that when the point is removed the implant material is already in place. When the cannula is removed, the implant material is embedded in the mid-substance of the tissue. The number of implant ends attached to the point can vary from one to any multiple desired for a given procedure, with two ends being preferred. Further, armed sutures (sutures with an attached needle) may be preattached to the removable point by a variety of methods including press fitting, adhesive, or heat shrink tubing. Multiple armed sutures (sutures with more than one attached needle) may be preattached to the point by these methods with the suture material extending into the cannula. These armed sutures include sutures with

needles disposed on either one or both ends.

Thereafter, the cannula is withdrawn from the tissue leaving the implant material in place therein to securely approximate and/or reinforce the separated ends of the tissue. Final closure of the edges of the defect may be accomplished by suitable means, e.g., small sutures, if necessary. However, the main implanted suture serves to support and distribute flexure and strain forces applied to the joined tissue to facilitate healing.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, referred to herein and constituting a part hereof, illustrate preferred embodiments of the present invention and, together with the description, serve to explain the principles of the present invention.

FIG. 1 is a side view of one embodiment of the present invention having a substantially linear cannula with removable trocar point.

FIG. 1A is an enlarged side view of one embodiment of the present invention for implanting a braided tubular ligament prosthesis using a linear cannula with the prosthesis attached to a removable taper point.

FIG. 2 is a side view of another embodiment of the present invention having an arcuate cannula with removable cut taper point.

FIG. 3 is a side view of still another embodiment of the present invention having a partially linear and partially arcuate cannula with a removable point having a guide wire attached.

FIG. 3A is a side view of an alternate embodiment of the present invention having the implant material fixed directly to the removable point.

FIG. 3B is a side view of an embodiment of the present invention wherein the guide wire extends through the cannula and has the implant material attached to a loop outside the cannula.

FIG. 4 is a side view of another embodiment of the present invention having an arcuate fluted cannula with a removable point and guide wire.

FIGS. 5-10 are perspective views of a tendon repair using apparatus in accordance with the present invention to implant a braided stay suture.

FIG. 11 is a side view of an embodiment of the present invention having two armed sutures preattached to a removable point.

FIG. 12 is an enlarged view of the removable point of Figure 11.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1-4 show a variety of preferred embodiments of the apparatus in accordance with the present invention. FIG. 1 represents a substantially

linear cannula 20 having a removable point 22 detachably positioned in a proximal end 24 of linear cannula 20. Removable point 22 is press fit with a slight interference into proximal end 24 to facilitate secure attachment and easy removal. One skilled in the art, however, would recognize that any releasable attachment means would be appropriate including, threading, twist on or breakaway lines.

Point 22 is formed in the shape of a trocar to ease entry into soft tissue. Other shapes and configurations are also useful including: conical, both convex and concave; arcuate conical; tapered; reverse cutting; side cutting; and flattened conical with a plurality of sharpened edges. In order to ease entry of the cannula into the tissue, the points are dimensioned at their base to have approximately the same diameter as the cannula to which they are attached.

Cannula 20 is dimensioned based on the particular application and the type of approximating or reinforcing material to be implanted. For example, in hand tendon repair, cannulas of 16 or 18 gage diameter in varying lengths are particularly useful for implanting suture material to join separated ends. For other applications such as larger tendons, muscle, soft tissue or ligament repair, size, shape, length and diameter may be varied as required.

FIG. 1A discloses an alternate embodiment of the present invention for implanting a braided tubular ligament prosthesis 21. A substantially linear cannula 23 encloses a portion of the prosthesis 21, one end of which is fixed directly to removable taper point 25. This point 25 is press fit in a similar manner to that described above with respect to the embodiment of FIG. 1.

FIG. 2 shows a substantially arcuate cannula 26 having a removable point 28 which is releasably attachable to a proximal end 30 of cannula 26. In this embodiment, point 28 is provided with internal threads 32 which are threadably engagable with external threads 34 formed on proximal end 30 of cannula 26. Alternatively, annular rings and grooves could be substituted for threads 32, 34 such that point 28 interfits over cannula 26.

A cannula 36 having a partially linear and partially arcuate shape is shown in FIG. 3. This embodiment of the present invention also includes a removable point 38 which is formed in the shape of an arcuate cone following the curve of cannula 36.

A guide wire 40 is affixed to the base of removable point 38 and extends through cannula 36, terminating in loop 42 at a distal end. This loop 42 may either extend slightly beyond the distal end 44 of cannula 36 (FIG. 3B) or remain within the cannula to facilitate attachment of an implant material (not shown) to be drawn through cannula 36

by guide wire 40.

Alternatively, an implant material such as, for example, a braided suture 41, may be fixed directly to removable point 38 as shown in FIG. 3A. This configuration would serve to pull the braided suture 41 directly into position simply by removing point 38.

Another embodiment of the present invention is shown in FIG. 4 wherein a cannula 46 is formed with a breakaway point 48. In this embodiment the entire assembly (cannula 46 and breakaway point 48) is formed as a single unit with a preformed breakaway line 50 to enable point 48 to be broken off after positioning, leaving cannula 46 in place. This assembly can be formed using known techniques such as, for example, extrusion, molding, etc. Appropriate materials include, stiff or reinforced plastics, aluminum, stainless steel, etc.

The breakaway point 48 of this embodiment is in the shape of a flattened cone with sharp edges 52. Further, flutes 54 are provided longitudinally along cannula 46 to aid and guide the assembly through the tissue.

FIGS. 5-10 illustrate the use of one embodiment of the present implant assist apparatus to repair a defect in a tendon using a braided type stay suture. FIG. 5 shows the tendon, generally 56, separated into a first end 58 proximate muscle tissue 60 and a second end 62 proximate the bone (not shown).

Referring now to FIGS. 6-7, implant assist apparatus 64, as shown disassembled in FIG. 3, is used to implant the braided stay suture 66 starting at the muscle tissue 60, through first and second ends, 58 and 62, respectively, to emerge from tendon 56 remote from second end 62.

Prior to initiating the repair procedure using this embodiment of the present invention, the implant assist apparatus is prepared by removing arcuate point 38 from cannula 36 such that attached wire 40 and wire loop 42 are exposed (not shown). A suitable length of suture appropriate for the procedure is selected. Typically, a length is selected such that when the suture is doubled over, about six inches of suture are exposed on each end of cannula 36. One end of the suture 66 is threaded through loop 42 and pulled until approximately equal lengths of the suture are disposed on either side of the loop 42. Both ends of suture 66 are threaded into proximal end 41 until the suture ends exit the distal end 44 of cannula 36. The suture 66 is then pulled (from the ends extending through distal end 44) until loop 42 enters the cannula 36 (through proximal end 41) and arcuate point 38 seats in the proximal end 41 of cannula 36.

The implant assist apparatus 64 is now ready to be passed into tissue across the site which is

being repaired. Point 38 is inserted into muscle tissue 60 at location 68 remote from first tendon end 58. The apparatus 64 is guided through the tissue, passing through both first and second tendon ends, 58 and 62 respectively (Figure 7), until point 38 emerges from the tendon at exit site 70 (Figure 8). At this stage, distal end 44 of cannula 36 should be exposed at entry location 68 and point 38 should extend out of exit location 70 a distance sufficient to expose proximal end 41 of cannula 36. See FIG. 8.

While holding cannula 36 near the exposed distal end 44, point 38 is detached until loop 42 containing suture 66 is visible. Suture 66 is then pulled carefully until approximately equal lengths are exposed from proximal and distal ends of cannula 36. By gripping one end of suture 66 (in this case the end extending from exit location 70) cannula 36 is pulled out of entry location 68 in the direction of arrow 72 leaving the suture 66 in position. See FIG. 9.

The ends of suture 66 are then tied off, preferably using oblong tying buttons 74 as shown in FIG. 10, to close the ends of the tendon defect to promote healing. Where desired, whipping sutures 76 may be used to close any unsatisfied ends of the tendon 56. Also, surgical needles may be attached to the free ends of the exposed suture and additional suturing and tying may be performed to fully anchor the suture and complete the repair.

Referring to FIG. 11, there is shown an embodiment of the present invention wherein a pair of double armed sutures (i.e. sutures with a needle at both ends), shown generally at 80, extend through cannula 88 and are preattached to removable point 82. As shown, the cannula 88 is arcuate, however, alternately the cannula 88 can be linear as in Figure 1. In this particular embodiment, two straight needles 86 are releasably preattached to point 82 by means of heat shrink tubing 84. The cannula is therefore dimensioned to have an inside diameter of sufficient size to receive adjacently aligned needles enveloped by shrink tubing. As shown in Figure 12, heat shrink tubing 84 fits around narrowed portion 83 of point 82 and tightly engages flange 85.

Suture material 90 extends through proximal opening 92 into cannula 88 and has a second pair of needles 94 attached to distal ends thereof. In this particular embodiment shown in the drawings, straight needles are used on both the proximal and distal ends of suture material 90. However, one skilled in the art will appreciate that a wide variety of needle types and shapes may be substituted.

In operation, after the pair of needles 86 are releasably preattached to removable point 82 by heat shrink tubing 84, the removable point 82 is removably inserted into the proximal opening 92 of

cannula 88 as described above with respect to other embodiments. The suture material may be dimensioned such that the distal end thereof is retained within cannula 88 or alternatively may extend outside the distal opening 96 as shown in Figure 11. After the cannula is emplaced within the subject tissue in the manner described above, removable point 82 is separated from the proximal opening 92 of cannula 88 exposing needles 86. These needles are then separated from the heat shrink tubing 84 on removable point 82 (e.g. by pulling them out of the end of the tubing). The cannula 88 may be withdrawn from the tissue in a distal direction leaving the pair of sutures 80 with attached needles in place to be used in the surgical procedure to be performed. This embodiment is particularly useful in procedures wherein multiple sutures with attached needles must be passed through tissue in close proximity to effect joining or repair.

#### Claims

1. An implant assist apparatus for implanting material in tissue to be reapproximated or reinforced comprising:
  - cannula means having a hollow body and an open proximal and distal end, said cannula dimensioned to receive the implant material; and
  - point means detachably fixed to said open proximal end of the cannula means for penetrating tissue.
2. An implant assist apparatus as in claim 1 further comprising guide wire means attached to said point means and extending into said open proximal end of the cannula means.
3. An implant assist apparatus as in claim 2 further comprising a loop formed in said guide wire means in an end opposite said point means and said implant material being releasably attached to said guide wire means and extending from said open distal end of the cannula means.
4. An implant assist apparatus as in claim 1 wherein an end of said implant material is preattached through said cannula to said point means.
5. An implant assist apparatus as in claim 1 wherein said cannula means is linear in shape, arcuate in shape or partially linear and partially arcuate in shape.
6. An implant assist apparatus as in claim 1

wherein said implant material is selected from the group consisting of sutures, prosthetic devices and tissue augmentation devices.

7. An implant assist apparatus as in claim 1 wherein said implant material comprises a braided suture. 5
8. An implant assist apparatus as in claim 1 further comprising suture means releasably attached to said point means through said cannula. 10
9. An implant assist apparatus as in claim 8 wherein said suture means comprises at least one needle attached to said suture. 15
10. An implant assist apparatus as in claim 8 wherein said suture means comprises at least one needle attached to each end of said suture. 20
11. An implant assist apparatus as in claim 9 wherein a needle of said suture is releasably attached to said point means by heat shrink tubing. 25
12. An implant assist apparatus as recited in claim 11 wherein said cannula is dimensioned to receive said heat shrink tubing enveloping said needles. 30
13. An implant assist apparatus as in claim 11 wherein said cannula is linear in shape, arcuate in shape or partially linear and partially arcuate in shape. 35
14. An implant assist apparatus as in claim 10 wherein said cannula further comprises at least one flute formed longitudinally therein. 40
15. An implant assist apparatus as in claim 14 wherein said point means is formed in the shape of a trocar or an arcuate cone. 45
16. An implant assist apparatus as in claim 8 wherein said point means is formed integrally with said cannula and is detachable therefrom.
17. An implant assist apparatus as recited in claim 10, wherein a pair of sutures extend side by side through said cannula, each suture having a needle attached to both ends. 50
18. Apparatus for implanting material in tissue for reapproximating or reinforcing defects therein for use in a method comprising the steps of: 55
  - providing cannula means having a hollow

body open at both ends and a detachable point at a proximal end thereof, said detachable point having implant material attached and extending into said hollow body;

passing said cannula means with detachable point and implant material into the tissue at an entry point remote from one side of the defect and out of an exit point in an opposite side remote from the defect such that a distal end of said hollow body extends from the entry point and a distal end extends from said exit point;

removing said detachable point from said cannula means and drawing the implant material out of the proximal end of said hollow body until the implant material is exposed at both the distal and proximal ends of the hollow body; and

withdrawing said cannula means from said tissue, leaving the implant material in place.

19. Apparatus for a method of implanting material as in claim 18 further comprising the step of anchoring the implant material to reapproximate or reinforce the defect.
20. Apparatus for a method of implanting material as in claim 19 wherein said length of implant material is at least partially contained within said hollow body.
21. Apparatus for a method of implanting material as in claim 20 wherein said implant material comprises a suture having a needle attached thereto, and wherein removing said detachable point from said cannula exposes said needle.

Fig.1

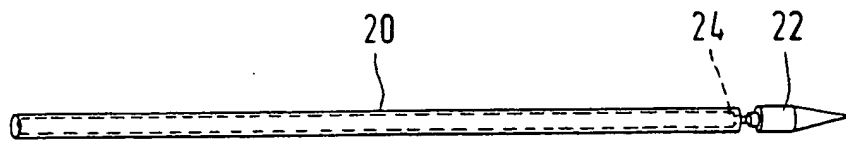


Fig.1A

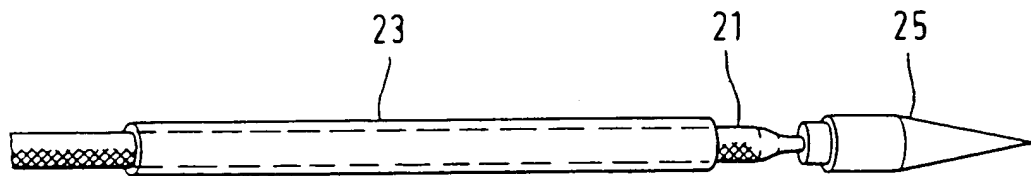


Fig.2

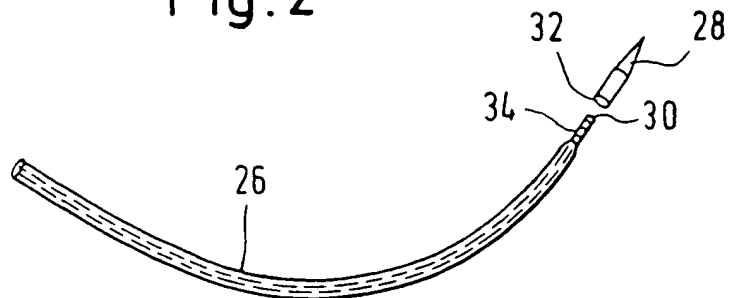


Fig. 3

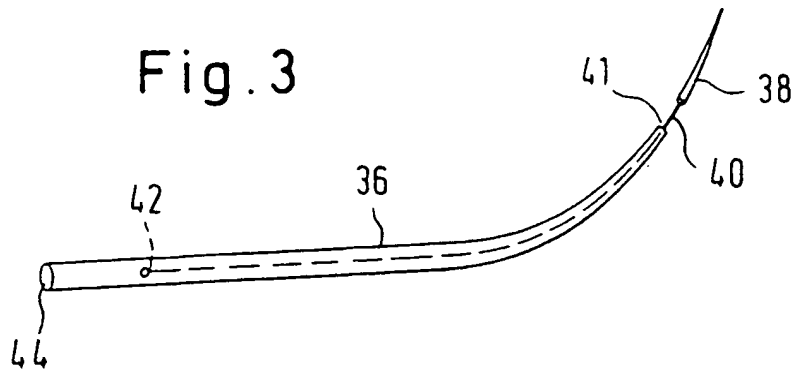


Fig. 3A

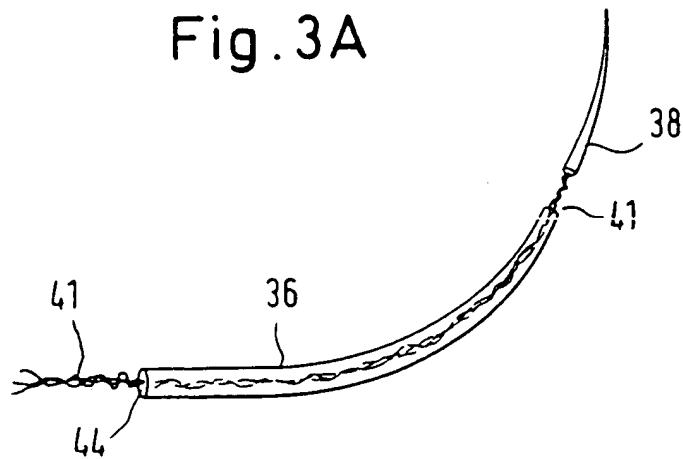


Fig. 3B

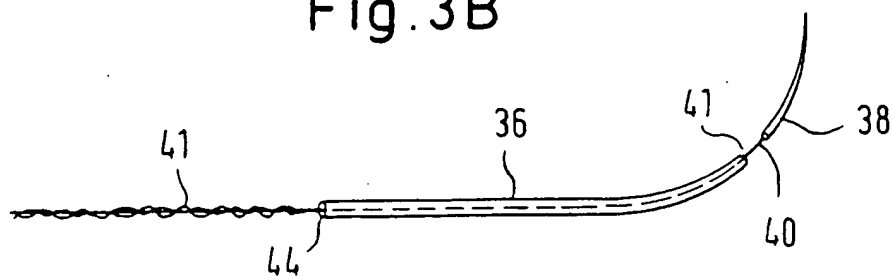


Fig. 4

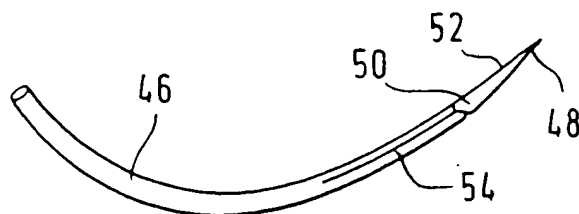




Fig. 5

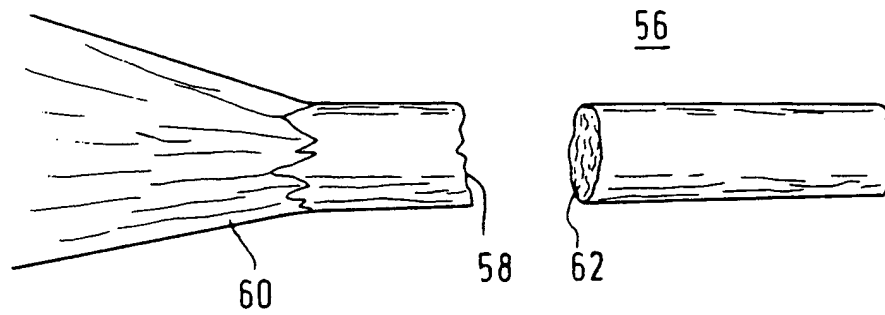


Fig. 6

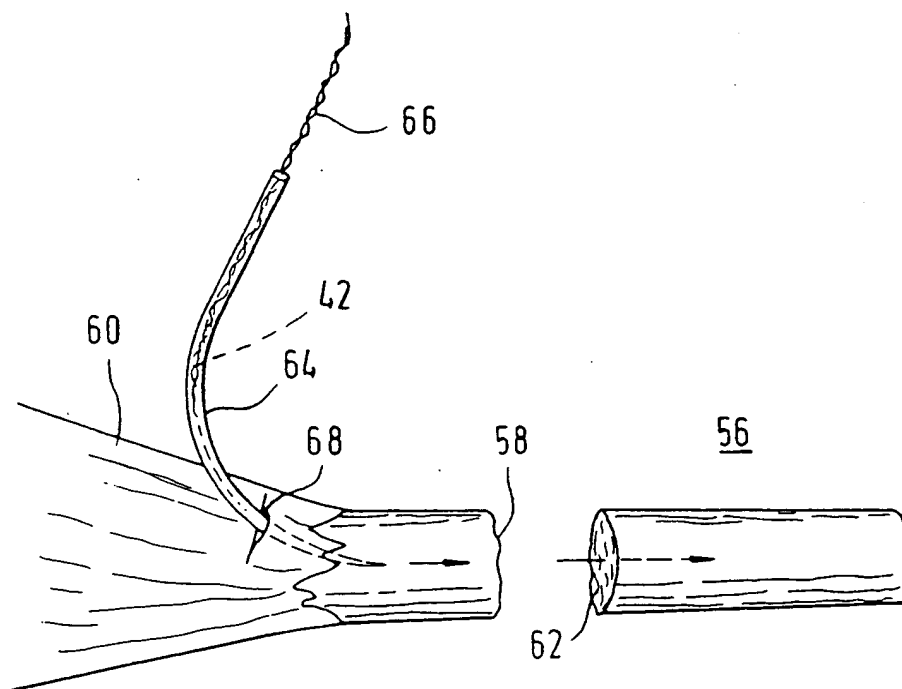


Fig.7

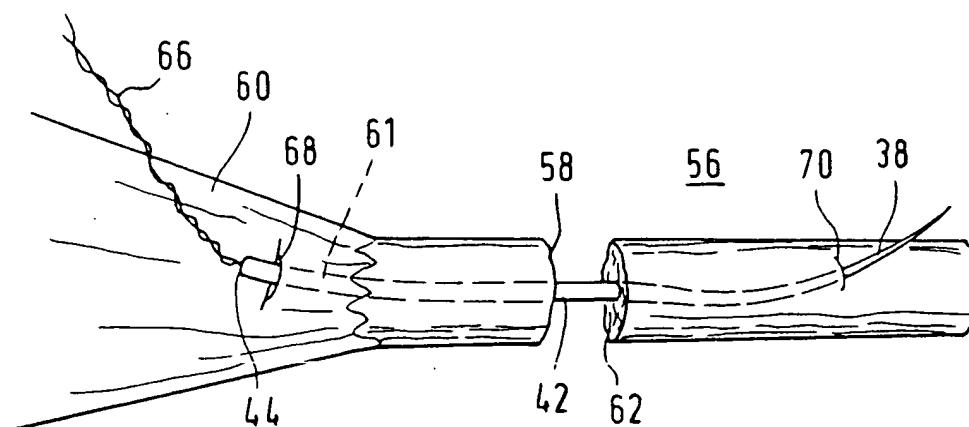


Fig. 8

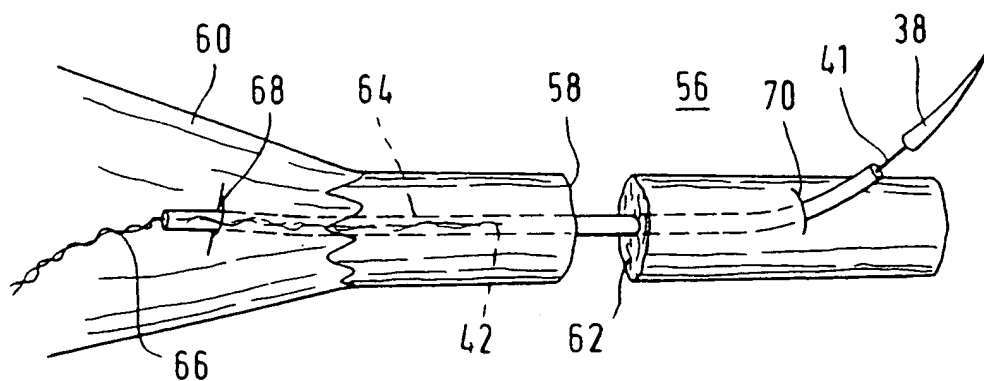


Fig. 9

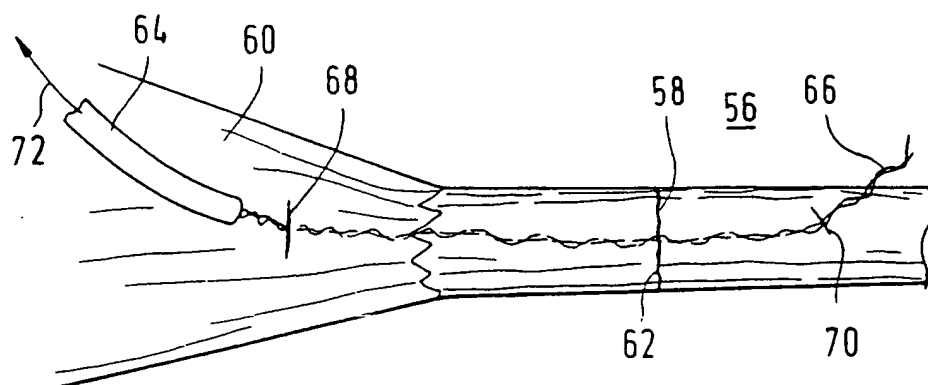


Fig. 10

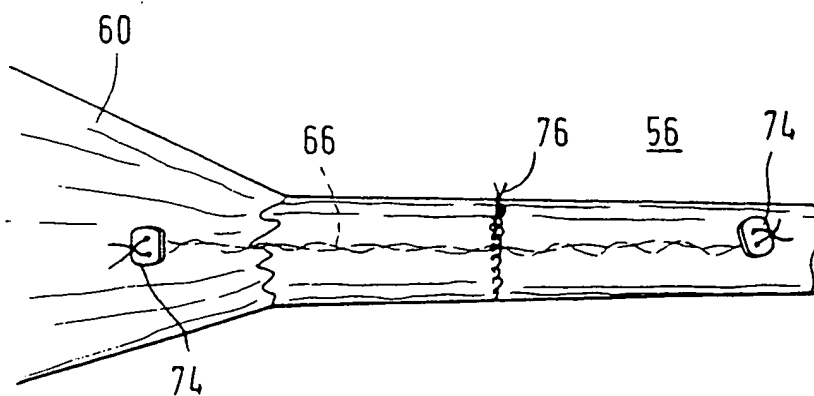


Fig.11

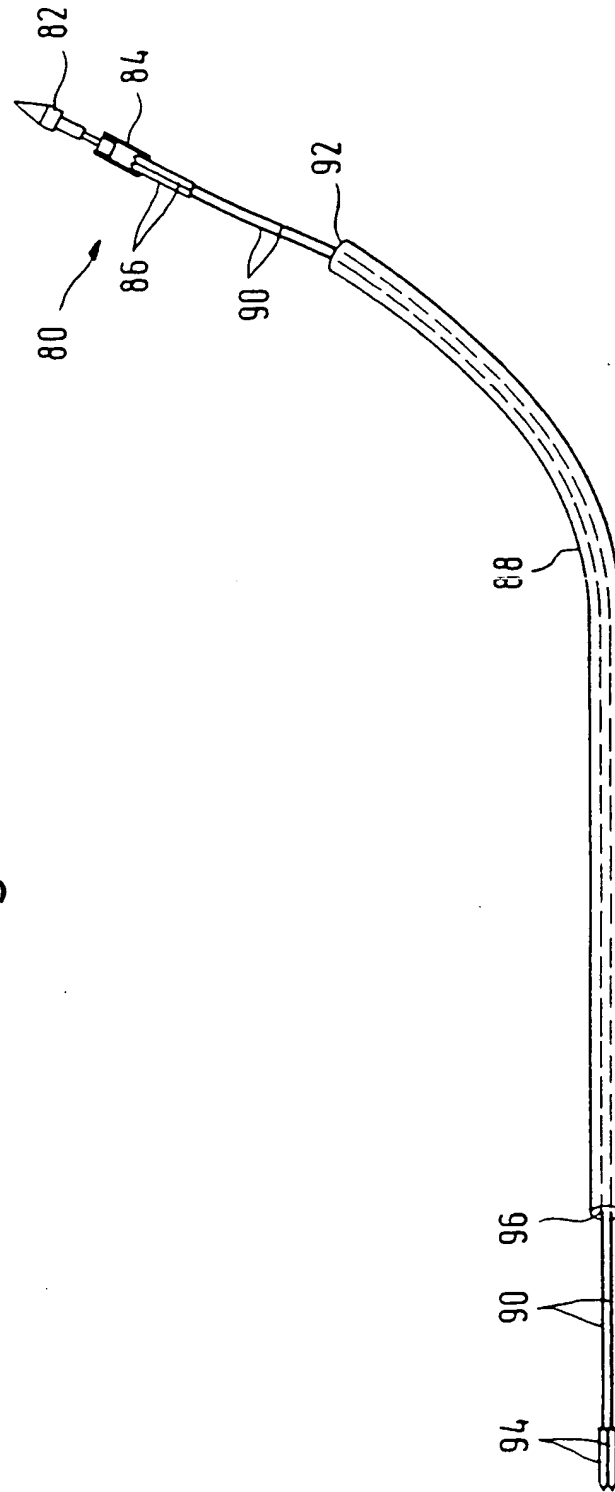
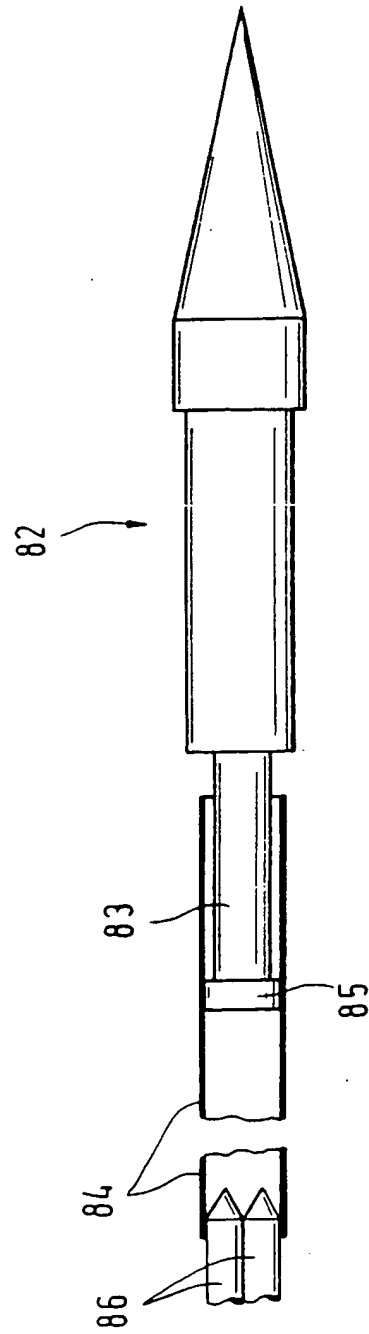


Fig. 12





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# PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention  
shall be considered, for the purposes of subsequent  
proceedings, as the European search report

Application Number

EP 91 11 4337

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 265 246 (BARRY) * Column 2, lines 30-42; column 3, lines 27-56; column 4, lines 33-36; figures 2,5-7,14 *	1,5,6	A 61 B 17/04 A 61 B 17/11 A 61 F 2/08
A	---	2-4,7-9,11,13,15-17	
A	US-A-4 932 962 (YOON) * Figures 4-6,10,11 *	1,16	
A	FR-A-2 422 386 (BUSCAYRET) * Page 6, line 16 - page 7, line 10; figures 4a-5b *	1,6,7,9,10	
A	US-A-4 799 483 (KRAFF) * Column 6, lines 43-49; figure 1 *	14	
A	US-A-2 833 284 (SPRINGER)		
A	US-A-4 392 495 (BAYERS)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			A 61 B A 61 F
INCOMPLETE SEARCH			
<p>The Search Division considers that the present European patent application does not comply with the provisions of the European Patent Convention to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of some of the claims</p> <p>Claims searched completely : 1-17 Claims searched incompletely : Claims not searched : 18-21 Reason for the limitation of the search:</p> <p>The apparatus for implanting material in tissue according to claims 18 to 21 is only defined as being (suitable) for use in a certain surgical method. No technical features to searched (obscurity).</p>			
Place of search THE HAGUE		Date of completion of the search 16-12-1991	Examiner KLEIN C.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : member of the same patent family, corresponding document			